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ABSTRACT

While women's representation in math and the physical sciences has improved over the past decade, it will be 20 years before women achieve equal representation at the bachelor's level in these fields. In a series of interviews conducted with students in college-level science programs in Montreal (Canada) community colleges, the majority of female students saw science education as a way of keeping their options open and did not appear committed to a life in the sciences. Despite the higher drop rate for women in science programs, there are no significant differences in achievement levels between men and women. In an effort to alter the attitudes which might influence women's persistence in the sciences, a project was undertaken to develop and implement a feminist pedagogical practice more conducive to women's learning. A teacher workshop was conducted to afford participants the opportunity to consider the significance of gender differences in the teaching of science at the college level, and to experience first hand a number of feminist pedagogical strategies. One important behavior encouraged of teachers was the practice of self-disclosure, by which teachers reveal themselves as people to their students and thereby make personal experiences pedagogically relevant. Another strategy emphasized in the workshop was the integration of informal writing in the science classes as a means of providing female students with access to the teacher, a place in the learning discourse, and an opportunity to develop confidence. A third strategy involved the establishment of permanent peer support partnerships of the student's own choice for work and study inside and outside the classroom. Such partnerships can encourage female discourse and disclosure with peers. Preliminary findings from a study of community college physics classrooms taught by teachers who completed the workshops on feminist pedagogical strategies revealed a consistent pattern of reduced anxiety, improved relationships between students and teachers, and increased enjoyment of the subject among both men and women. (PAA)

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Feminist Pedagogy and the Teaching of Science:

An Experiential Workshop

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An Experiential Workshop
With Arlene Steiger and Fran Davis

The workshop was designed to afford participants the opportunity to consider the significance of gender differences in the teaching of science at the college level. Participants experienced first hand the pedagogical strategies which are being tested in this research, funded by the Quebec Ministry of education (PAREA), and involving Montreal area Cegep students: that is, self-disclosure, writing in the learning process, and peer support partnerships.

In order to model the praxis of feminist pedagogy, workshop leaders began by asking participants to write freely about their interests and concerns regarding gender and science education, and then to discuss their writing with one other person in the group. Following these activities, each set of partners was asked to introduce themselves to the group and to identify one major concern on which they had agreed. Since most of the concerns thus compiled were expressed as questions, it was agreed that the workshop would turn to consider some of the issues which had emerged from the research of the workshop leaders.

Women in Science Programs: Percentages and Problematics

The general concern about the under-representation of women in the sciences finds support in the data on women's participation in higher education. In the latest statistics to be released by Industry, Science, and Technology Canada (1991), one can continue to trace a now familiar pattern across all disciplines: the more advanced the degree, the smaller the proportion of women recipients. The significance of the trend is underscored by the fact that women's labour force participation and employment opportunities are much more closely tied to their level of education than are those of men. Of particular concern, however, is the fact that this trend finds dramatic expression in the pure and applied sciences, where the relative absence of women is already apparent at the bachelors level. In 1989, women earned only 13% of the bachelor degrees in engineering and only 28% of the bachelor degrees in math and the physical sciences.

While it is true that women's representation in these areas has improved over the past decade, at the present rate of increase, it will be 20 years before women achieve equal representation at the bachelor's level in these fields; and, according to at least one estimate, it may be 100 years before they attain the level of expertise required for filling faculty positions in universities. Of course, all of these projections assume the present rate of increase, which may in itself be optimistic.

In this project, the researchers have explored some of the motivations underlying students' choice of the sciences as an area of study at the college level. Of the hundreds of entry

level science students interviewed by the researchers in several Montreal Cegeps, only a small minority speak of a love for science per se and their very positive attitudes toward the sciences do not, in themselves, predict persistence in the sciences. The vast majority of the students interviewed see science education as a means to keep their options open, and their interviews reflect their own recognition of the higher status of science with respect to the other disciplines at the college level. In this sense, the following voices are typical:

> I remain in science to keep my options open (that is what everyone has been telling me to do). My friends, most of whom are not in science, respect my choice and think of me as very smart.

> Why am I taking science? I feel like I have to. It's sort of at the top of things (like the most difficult program), and if I cannot handle it, I can work my way down to other programs ... Friends of mine who are not in sciences sort of look up at us - in a way. I really don't know why because I honestly believe anyone can do it.

On the basis of these interviews, it is possible to say that, by and large, most students at this stage are not deeply committed to a life in the sciences. However, when they are, they tend to be connected to the sciences by a "career glue" - the desire to be an engineer, for example - and, in this, boys are much more likely to be "stuck" than girls.

Sheila Tobias, in her study of students who do not opt for the sciences titled They're Not Dumb, They're Different (1990) observes that students who stay in science frequently do so for reasons unrelated to their current education. The results of the interviews in this project support her findings. For example, in interviews with students in electrotechnology programs, a field widely recognised as an avenue of upward mobility for working class students, 100% of the men who were interviewed reported that they had always played with electronic gadgetry. In a very real sense it can be said that a lifetime of experience had prepared these young men to make their choices. Out of a class of 80 students in electrotechnology, there were only 2 women. Neither had ever played with electronic gadgetry; both were in the program on the advice of a guidance counsellor.

In general, the students who were interviewed as part of this project, women most especially but men as well, seem to be waiting. While it is true that the men are more firmly connected to the area by virtue of specific career aspirations, it is also true that in a written survey of students' attitudes to physics, both men and women reveal themselves to be remarkably open and receptive to what the college experience of the sciences may

bring. For this reason, and despite the fact that there are clearly many forces responsible for the under-representation of women in the sciences, the current research project has sought to explore the extent to which women's attitudes toward science and their persistence in the sciences might be affected by the classroom experience.

In focussing upon the educational experience of women per se, it is important to emphasize that women do not constitute a disadvantaged group in the traditional sense of the term. Despite the higher drop rate for women in the sciences at every level of the educational system, there are no significant differences between women and men with respect to achievement as measured by marks (Lafortune,1986; Mura,1986). The present research therefore takes as its focus an attempt to alter a range of attitudes which might impact upon women's commitment to persist in the sciences, and it hypothesizes that this objective can be achieved by developing and implementing a pedagogical practice more conducive to women's learning. The development of this pedagogy has been guided in large measure by the principles of feminist pedagogy and, in particular, by the feminist vision of education as a transformative process, an important goal of which is to empower the individual. The strategies which have been developed are now being tested in several physics classes in the Cegep system.

Including Affect in Science Education: Using Self-Disclosure

One important component of these strategies is the systematic integration of the affective dimension in learning. The researchers emphasize that this can be accomplished in many ways, but one important behaviour required of teachers in the feminist classroom is the practice of self-disclosure, the process by which teachers make the personal pedagogically relevant. The researchers have examined the impact of self-disclosure in several different contexts. In an earlier research project (Davis, Steiger, and Tennenhouse, 1989), 25 teachers from a range of disciplines, including but not limited to the sciences, were asked to keep systematic records of the ways in which they revealed themselves as people to their students. Teachers were also asked to practise self-disclosure in their written comments to students: using I- statements, engaging in a dialogue with students' work rather than judging it from the point of view of one who has "mastered" the material.

The results of this assessment have informed the current research project. It is clear that when teachers' self-disclosures work, they serve to relax students, to make them more attentive, and to make them more willing to participate in the classroom process. However, it is also clear that many self-disclosures do not achieve these ends. Long, inappropriate self-disclosures have the opposite effect, as do poorly timed revelations. In the current research project, teachers are told that the most pedagogically useful self-disclosures are often not very intimate. Many of the most effective self-disclosures allow

students to come to know the teacher as a person who is also engaged in a working and learning process; and such revelations can and should be made over time. For example, teachers report positive results when they share problems which they themselves have had in approaching a specific topic. Trial and error often reveals when such disclosures make effective introductions to a topic, and when they function better as shared moments once the students themselves have begun to explore their own responses to the area.

By creating a space for the personal, through lecture, discussion, and writing, teachers help to democratize the classroom, because a process is set in motion by which students feel empowered to speak. In physics classes, this has meant that teachers hear a wider range of student needs and concerns. As a result, teachers are frequently able to respond more promptly and more effectively to their students, but they are also more likely to be forced to confront the disaffection from education which many of their students feel. Gender and other differences of power are also given space for expression.

The workshop leaders stress that gender differences in the classroom cannot be ignored. In fact, both teacher observations and student interviews suggest that men and women students may react differently to various pedagogical strategies. The interview data, in particular, offers evidence of the different patterns of psychological development for each of the genders which has been traced in the work of authors such as Carol Gilligan, Nancy Chodorow, and Dorothy Dinnerstein. These theorists argue that to the extent that children are mother-raised in our society, men tend to develop an identity which is based upon difference and separation from the mother; women are more inclined to develop an identity within the context of connection. One must pose the issue not in terms of men versus women but in terms of a continuum, on which masculinity and femininity represent different balances of separation and connectedness. Under the present system of social arrangements for child-rearing, it is not surprising to discover that more men are represented on the masculine end of the continuum, more women on the feminine side. These gender differences come into play in the classroom. The words of a young man, recently interviewed in a physics course, serve as illustration:

> You don't go to see the teacher because you don't want him to know your situation. If you let them know you don't understand something and are having trouble with all this, and they had thought before that you understood it and that you just weren't working hard enough, then when they find out you don't know it that could affect how you do.

It is possible to see in this young man's coping strategy a masculine system of defense, oriented toward protection of the

self through distance and separation. Clearly, the personalizing of relationships between teacher and student in the classroom will be experienced in a particular way by him and by those who are like him. However, it is important to say that the vast majority of students, both men and women, experience more open and personalized connections with their teachers as positive. The surveys of the hundreds of students who have participated in the experiment to date show that, in the experimental groups, students, both men and women, develop significantly more positive attitudes toward the physics teacher. Within the context of what is known about gender difference, however, it is possible that the improved relationship with the teacher may be more important for women.

It is interesting that a significant difference between men and women has emerged in the research with respect to the use made by each of office appointments. According to preliminary findings, of all the students participating in the project, 30.9% of the men never went to their physics teacher's office but only 4.9% of the women never sought out such individualized attention. Traditionally, such statistics have been read as evidence of feminine insecurity, manifested in various clinging behaviours. The present research offers a different interpretation and suggests that this data is best understood as evidence of a preference for a more "connected" style of learning, a preference which Belenky has argued is more frequently found among women learners (Belenky et al, 1986).

To say that there are gender differences and that these differences do manifest themselves in the classroom is not to say that they are either fixed or frozen. It must be emphasized that gender differences are given significance when they are placed in a concrete social context with all of its political dimensions. It is significant, for example, that in psychology, we define healthy adulthood in masculine terms, as separate and autonomous. It is significant that the distanced relationship between student and teacher is the model for student teacher relationships in post-secondary education and that, particularly in academe, the most valued form of writing and speech is formal "objective", distanced. It is significant that this kind of distance which Evelyn Fox Keller (1985) has suggested is what we call objectivity is widely perceived to be central to the sciences; and that science has become an important means by which power can be accessed in our society. It is clear then that a pedagogy of empowerment must address itself to the classroom as a political context within which both men and women function and are expected to learn.

Gender Inequities in the Classroom

An example of some of the difficulties facing young women in introductory physics courses in Cegep may be illustrated by a short passage from an interview with one female student:

Interviewer: Why did you take physics?
Student: I want to be a pediatrician. I don't know if I'm going to make it though.
Interviewer: How have you felt about your teachers?
Student: Last semester my teacher didn't seem to care. If you asked him a question he'd get upset. I'm a shy person so it's hard - if they don't care I get discouraged. But I guess it's me and my head. It's not physics.
Interviewer: How do you think your teachers have felt about you?
Student: They probably felt I wasn't trying hard enough but it wasn't true. But I'm closed in, so they couldn't know me personally.

Behind almost every remark made here by the student is the spectre of low confidence, leading her to doubt her ability and to derogate her efforts. Though the example is an extreme one, it is not atypical. Many persuasive studies suggest that confidence is the central gender-related predictor of persistence in science and mathematics, and these same studies show that women's levels of confidence are lower than those of men (Meece, 1982; Mura, 1986). Attributional theorists and researchers such as Frieze (1975), Crombie (1983), Erkut (1983), Vollmer (1984), and Licht (1987) have shown that women tend to internalize failure and to externalize success, a pattern of thought which leads to low confidence in their chances for future success in the field.

One particularly interesting study compiled by Greenberg and Lake for the Association of American University Women (1990) explores the nature of this gender difference with respect to its effect on action and ability development. The study shows that girls' confidence levels, already lower than those of boys in elementary school, decline further in adolescence and never really recover. Sources of boys' superior confidence appear to centre around more positive attitudes to physical changes, more ego-investment in activities such as sports, and greater willingness to imagine future potential for action and control. Girls, on the other hand, view their physical changes more negatively, place much more importance upon how they look than in what they do, and are thus less able to imagine future accomplishments. Furthermore, the study shows a strong relationship between the liking for science and math and these students' self-esteem: those who feel good about themselves are much more likely to enjoy science and math, and vice versa.

In the research presently being undertaken by the workshop leaders, a similar conflation of self-confidence and competence in science has been observed. When students are asked how confident they are about their ability to do physics, males tend to express much greater certainty than do females. Though some of

this gender difference might be explained in terms of male bravado and female diffidence, the short and long range effects of these attitudes cannot be overlooked. These male students who deny self-doubt and soldier on through high-stress, lock-step college physics curricula and multiple problem sets on timed exams are much more likely to afford themselves full opportunities to demonstrate their abilities than females who continually question their abilities, their knowledge and their work habits.

Another of the issues illustrated in the interview excerpt with this young woman is the isolation experienced by females in large mixed classrooms. This student is unable to communicate with her teacher: she cannot ask questions, nor can she communicate her efforts and concerns. Again, she is not atypical. Research on speech patterns in the large mixed class continues to demonstrate that males talk more, talk more assertively and therefore control the discussion, and interrupt when women are speaking (Spender, 1980; Laforce, 1987). Patterns of teacher intervention illustrate that these gender differences continue to be inequitably mediated, with teachers giving greatest attention to white middle class males, less attention to marginalized males, still less attention to white middle class females and least attention to marginalized females (Concordia University, 1991). When, as Adrienne Rich (1979) has pointed out, discouraged by lack of serious attention, some women sink entirely into silence, their low self-confidence is further eroded by the experience.

As if these feelings of inferiority and marginalization were not enough, silenced female students suffer further disadvantage when they are excluded from the learning discourse of the classroom. Not only has language been shown to be essential in the learning processes of young children (Britton, 1970), but the importance of informal "student talk" has been emphasized by educational researchers in literacy across the curriculum (Fulwiler, 1980; Martin, 1976; Shor, 1987) as well as in specific disciplines like biological and physical science (Brooke and Driver, 1986; White, 1988) and mathematics (Baruk, 1985). Students who cannot participate in the process are not afforded equal opportunities for learning.

Strategies for Using Writing in the Learning Process

One of the ways to provide female students with access to the teacher, a place in the learning discourse, and an opportunity to develop confidence in their own learning processes is to integrate informal writing into science classrooms. Writing has been shown to enhance learning in all subject areas: it is active; it can link affective and cognitive processes; it links new with existing knowledge; it forces us to be explicit or confess ignorance; and it is permanent, and can be reflected upon (Crowhurst, 1990). Writing to learn captures female students because it guarantees a space for everyone; its informality

reduces tension and competition which studies continue to demonstrate as a difficulty for women (Lenney, 1983; Laforce 1987); it is a skill girls often learn early and well (Laforce, 1987).

The researchers stress the importance of emphasizing learning processes rather than written products. Student writing should be read, rewarded, discussed in class, shared sometimes with other students, and responded to by the teacher. It should not be corrected or graded, or low confidence students will be discouraged from communicating their real feelings, problems or thought processes. Small units of the total course grade can be set aside for writing to learn: students can earn these marks simply by doing the writing, a process which helps them learn, whether they write well and cover profound issues or whether they do not.

The particular writing strategies suggested by the research are five minute free-writes, journals, collective class-logs, and question/answer box writing. The last two strategies have been most successful in science disciplines. The collective class-log requires students to write once a week or once every two weeks on some aspect of the subject matter and to file their writing in a loose leaf binder kept on reserve in the library. Students tend to write about their difficulties, their interests, television or newspaper items which relate to what they are studying, and so on. After a few weeks, they begin to read one another's work and to dialogue with each other about the subject. In the physics project in which the researchers are presently involved, the question/answer box has been most useful, as students write directly to the teacher about specific problems they are having or have satisfactorily solved. The teacher can answer the questions, use the questions as a guide to lecture material, issue a personal invitation to the student to come for office help, and so on. Student isolation is dramatically reduced, as students such as the low confidence woman quoted above take full advantage of the strategy and are able to experience the interested attention of the teacher.

Peer Support Partnerships

Space can also be provided for women when students are directed to form permanent peer support partnerships of their own choice for work and study inside and outside the classroom. Students who cannot speak up in large mixed groups are very comfortable talking with a peer, and if the teacher is able to design tasks which allow for students to talk through problems together, the gendered discourse of the classroom is considerably modified. Here, as with the writing strategies, it is important to stress the process rather than the product. Completed partnership work should be rewarded with marks rather than graded for quality, since the point of the exercise is comfortable and supportive participation rather than mastery of skills and content. Keeping the units small, with three as a maximum number

of students in a partnership, reduces the possibility of reproducing gendered discourse. The connected learning modes of many young women and the importance of relationships in their scheme of values, as was discussed in the prior section on self-disclosure, renders this strategy particularly effective for them.

Effects of the Pedagogy

Preliminary findings in the research project show a consistent pattern of reduced anxiety, improved relationship with teachers, and increased enjoyment of subject in those physics classes in which these strategies are used. These results appear to be true for both the men and the women in these classes. The researchers would argue, however, that, given the current understandings about female learners in science, these changes in attitude are more important for women than for men, and may mark the edge of a shift in the education of women in science.

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